

REVEGETATION

- **Soil Amendments**
- **Non-Woody Plants**
- **Woody Plants**
- **Mulch**

SOIL AMENDMENTS

DEFINITION

Soil amendments are substances that indirectly aid plant growth by improving the quality of the soil. Amendments include lime, fertilizers (including organic manures), and approved special wastes such as sewage sludge and power plant fly ash.

PURPOSE

Soil amendments are used to increase the speed and success of revegetation. Plant nutrients can be provided, such as nitrogen, phosphorus, potassium, etc.; soil pH or acidity can be corrected; and changes in soil texture can be made in order to improve water-holding capacity and decrease soil compaction.

REGULATORY REQUIREMENTS

Soil amendments must be applied to regraded areas in accordance with 405 KAR 16:050 and 18:050, Section 5; that is, in a manner sufficient to sustain the approved post-mining land use and to sustain a vegetative cover that meets the requirements of 405 KAR 16:200 and 18:200.

The application of special wastes must be in compliance with land-farming regulations 401 KAR 45:030; 050, 070, and 100. All land-farming sites in which repeated applications of organic wastes are planned must also be permitted through the Kentucky Division of Waste Management and operated by a certified land-farming operator.

IMPLEMENTATION

All soil, water, and special waste analyses referenced in the sections that follow should be performed by a qualified laboratory using standard methods approved by the Cabinet. (Soil and special waste laboratories are not certified in Kentucky.)

Lime

Lime is used to neutralize acidic mine soils. The rate of lime application should be sufficient to raise soil pH to a value no lower than 6.4 for all land uses. Liming rates for mine soils as determined on the basis of buffer pH values appear in Table 9.

Table 9. Limestone Rates for Soil-buffer pH Readings

Buffer pH readings	Agricultural limestone (tons/acre) required to adjust soil to pH 6.4
6.7 - 6.3	2-4
6.3 - 5.9	4-6
5.9 - 5.3	6-8
5.3 - 5.0	8-11
5.0 - 4.5	11-15
4.5 - 4.0	15-25
below 4.0	25*

* When lime rates are 25 or more tons/acre, refer to section on Lime Requirement for Highly Acidic Spoils in Agr. 40.

Quality agricultural limestone is the liming agent of choice. By definition, such limestone contains sufficient calcium and magnesium carbonates to be equivalent to not less than 80 percent calcium carbonate. It must be fine enough so that not less than 90 percent passes through a U.S. Standard No. 10 sieve, and not less than 35 percent passes through a U.S. Standard No. 50 sieve. Lower quality lime may have a lower cost; however, larger quantities will be required to achieve the target pH. Consequently, lower purchase costs may be offset by higher transportation costs.

Suppliers will often apply lime. Broadcast spinners mounted onto a haul track can be used to spread the lime at an even rate. Disking is the primary method used to incorporate lime into the soil. Lime should be incorporated into the topsoil to a depth of at least six inches. Incorporation not only increases the affected zone to allow better rooting of plants, but it also minimizes lime loss via rainfall runoff. Lime should not be applied under wet soil conditions because it is difficult to incorporate uniformly into the soil.

Fertilizer

The three primary plant nutrients are nitrogen (N), available phosphorus (P_2O_5), and water-soluble potash (K_2O). Mixtures of fertilizer materials are commercially available; their grade or content is expressed in weight percent as N:P:K.

Nitrogen should be applied at the rate of 60 lb of N/acre for fall or spring seedings, with a topdressing of 30 lb/acre six months later. Additions should be applied as pounds of N and not pounds of fertilizer. For example, 100 lbs of 46-0-0 contains only 45 pounds of nitrogen. An additional 30 lb/acre should be applied during the spring of the second growing season when ground cover is the only revegetation objective.

The rates at which available phosphate and potassium (potash) are applied are determined on the basis of soil tests and intended land use. Fertilizer recommendations for vegetative covers to achieve either erosion control or hay and pasture land use are listed in Table 10.

Table 10. Fertilizer Requirements for New Seedlings^a

Test level (lbs/acre)	lbs P_2O_5 and K_2O to apply per acre ^b			
	Surface Cover		Hay and Pasture	
	P_2O_5	K_2O	P_2O_5	K_2O
Very Low (below 10P; 75K)	120-140	30-60	150-200	60-90
Low (10-30P; 165K)	100-120	0-30	100-150	30-60
Medium (31-60P; 165-250K)	50-100	0	50-100	0-30
High (above 60P; 250K)	0-50	0	0-50	0

a) If soil tests are very low, retesting is recommended prior to planting trees since additional P_2O_5 may be needed to maintain surface cover.

b) For alfalfa production, rates should be increased to 20-40 lbs P_2O_5 and 20-40 lbs of K_2O /acre.

Fertilizer is most simply spread in the dry, granular form. Modest incorporation is desirable but not required. It should not be applied when soils are wet. A salt solution forms when water and fertilizer are mixed that can significantly reduce the percentage of seed germination, especially those of grasses. The effectiveness of bacteria inoculated on legumes is also reduced.

If hydroseeders are used to broadcast seed, the slurry pH should be kept above 5. For a tank holding 1000 gallons of water, the pH should be above pH 5 if 100 pounds of calcium hydroxide (hydrated lime) were added to the tank mix and mix for at least 15 minutes prior to adding the bacteria inoculant, use two 6.7 ounce packages of inoculant, and spread within three hours. If delays exceed this time limit, both seed and inoculant should be added again as the germination would likely be significantly reduced and poor stands will likely result. It is not recommended to apply fertilizers and seed in the same tank mix when hydroseeders are used.

Special Wastes

Special wastes, especially sewage sludge and fly ash, are sometimes used to improve mine soils and topsoil substitutes. The suitability of wastes for land-farming is determined through a series of chemical and physical analyses as specified in the land-farming regulations. Heavy metal concentrations in waste materials are of particular concern because of their potential to cause toxicity in plants as well as the potential to pollute ground and surface waters. Information on waste material composition and soil test results are then used to calculate land-farming application rates.

The advantage of sewage sludge is that it generally behaves as a slow-release fertilizer with 15 percent of the total nutrients released the first year, 15 percent of the remaining the second year, 10 percent of the remaining the third year, and 5 percent of the remaining in the fourth and fifth years. Sludge can be applied with a manure or lime spreader and disked or chisel plowed to ensure incorporation.

Although fly ash has been found to offer little nutrient benefit in terms of N, P, or K, it has been used successfully as a neutralizing agent in acidic spoil. It should not be assumed that all fly ash has liming properties. The material should be tested prior to its use. Fly ash may be used to change the texture of the soil because it is largely comprised of silt-sized particles.

MAINTENANCE

Booster applications of lime and fertilizer may be beneficial as determined on the basis of soil test results. Requirements for land-farming management as specified in 401 KAR 45:100, Section 6 and 401 KAR 48:200 Section 8 must be met, if applicable.

NON-WOODY PLANTS

DEFINITIONS

Non-woody plants refer to low-lying herbaceous grasses, cereals, and legumes. Legumes differ from other plants in that they fix nitrogen from the air into the soil, thereby providing a valuable nutrient. Non-woody plants can be classified as either annual or perennial. Annuals live only one growing season, and for that reason are used for temporary vegetative cover unless they are capable of reseeding themselves, such as Korean or Kobe lespedeza. Perennials live multiple growing seasons, and some may produce seed that helps to keep an adequate stand.

PURPOSE

Non-woody plants can be used for both temporary and permanent revegetation of mined lands. Temporary ground cover is used to meet the revegetation timetable as specified in the MRP for the purpose of binding soil and reducing or preventing soil erosion and the sedimentation of drainage ways. Permanent ground

cover is designed not only to prevent erosion, but also to meet the objectives of the post-mining land use plan as specified in the MRP.

REGULATORY REQUIREMENTS

Revegetation of land affected by coal mining must meet the criteria set forth under 405 KAR 16:200, including requirements for temporary and permanent vegetative cover, species selection, establishment schedules, and success standards TRMs #19 and #21. A diverse, permanent vegetative cover must additionally meet the requirements delineated under 405 KAR 16:180 Protection of Fish, Wildlife, and Related Environmental Values. Certain areas on mines may have to meet additional requirements mandated by the Kentucky Division of Water under CWA Section 401 certification conditions for restored/replaced wetlands and riparian zones.

IMPLEMENTATION

Revegetation is required on all disturbed surface of soils and/or spoils. Seeding must be done as soon as weather permits and after soil amendments have been applied. Deadlines for these activities should be listed in a timetable within the MRP. In most cases, especially more steeply sloping sites, a fast-growing cover crop is sown along with the permanent species in order to protect the soil from erosion until the permanent crop is established. Such a practice could increase available moisture for the permanent grasses and legumes. The local agricultural extension agent (Appendix F) can recommend products and application rates for this purpose.

Revegetation activities include:

- Species Selection
- Seedbed Preparation
- Legume Inoculation
- Sowing

Species Selection

Seeding mixtures, rates, and timetables should be specified in the MRP. Mixtures will be tailored to meet seasonal variations in temperature and precipitation. Cool weather plant species can be sown in the fall or spring; warm-season species should be sown during the early summer months. Other site-specific factors considered in species selection in addition to the post-mining land use are tolerances and needs for soil pH and water-holding capacity, availability of nutrients, sunlight, and potential for grazing. Tables 11 and 12 summarize some suggestions for seeding mixtures and rates for eastern and western Kentucky coal fields by season, including both temporary and permanent species. In addition, TRM #21 is the guidance document (1995) published by the Kentucky Division of Forestry, Department for Surface Mining Reclamation and Enforcement, and Department of Fish and Wildlife Resources that also suggests plant species, distribution patterns, seeding rates, and planting arrangements. Caution should be exercised in the purchase of seed mixes marketed as "strip mine" mixes. Some companies may use this outlet to dispose of seed varieties with poor germination and performance.

Seedbed Preparation

Disk, harrow, or chisel plow topsoil to freshly prepared seedbed. Shallow ripping may be needed for compacted topsoils when scraper pans were used, (see Scarification).

Legume Inoculation

Legumes are an important component to any seeding mixture because they "fix" nitrogen from the air into the soil. This is accomplished by means of nodules on plant roots that are formed by soil bacteria called Rhizobia. Topsoil that has been stripped and stockpiled generally lacks enough living bacteria necessary to support this cycle. Therefore, it is critical that legume seed be inoculated immediately before sowing (and no more than 24 hours prior).

Different types of Rhizobia are required for the different legume species. The correct one should be used. Inoculants for birdsfoot trefoil, crown vetch, locust, and lespedeza may need to be specially ordered a few weeks in advance of seeding because they may not be available from the seed dealers. Check the date on the package to be sure it has not expired. Keep packages out of heat or direct sunlight (e.g., truck windshield, car trunk). Refrigeration is recommended.

Legume growth is improved when a "sticker" is used to bind the inoculant to the seed. Stickers may be purchased or made by the operator by mixing one part granulated white sugar, molasses, or syrup to nine parts water.

All seed should be sufficiently wet with the sticker in a wheelbarrow or other large container. Do not use too much sticker so that the seeds will stick together. Next, mix the inoculant (six ounces per 25 pounds of seed). Plant as soon as possible.

Hydroseeding inoculated seed has had limited success. Because of the dilution necessary to hydroseed, quantities of inoculant should be increased by two to five times in order to be effective. Seed should not be mixed with fertilizers because the salts will kill the bacteria within a few minutes. The inoculant just prior to starting the seeding operation, (see Fertilizers for method of pH adjustment).

Sowing

Seed should be planted at the rate and time specified in the MRP. Seeding can be accomplished using hand-operated broadcast or drill seeders, or tractor-mounted fertilizer or lime spreaders. Grasses and legumes should not be covered deeper than one-fourth inch.

If a source of clean water is available, a hydroseeder is easier and safer for use on steep slopes. Through the use of hydroseeding, seeding and other treatments can be accomplished in one application. Inoculated legumes or grasses should not be mixed with fertilizers or pesticides. Grains should be sown to a depth not to exceed one inch. Excess use of mulch with seed will often result in poor stands due to poor soil/seed contact.

MAINTENANCE

Revegetation success can be measured using procedures provided by the Kentucky Department for Surface Mining Reclamation and Enforcement's TRM #19 (1991). Poor stands should be resown following re-evaluation of soils and/or spoils in terms of acidity and fertility. As noted above, certain areas may need to meet requirements mandated by the Kentucky Division of Water.

Table 11. Useful Grasses and Legumes for Kentucky

The following is a brief description of several grasses and legumes considered useful in surface-mine revegetation. The reader should be aware that new varieties of species continue to be released on a periodic basis.

Cool Season Grasses for Permanent Cover

Species: Tall Fescue *Festuca arundinacea* L.
Varieties: KY 31, Kenhy, Festal, Johnstone
Characteristics: Long-lived grass species that is somewhat drought and acid tolerant (pH 4.5-8.5). May be established in fall or spring. Gives good ground cover; however, should be used only when hay cropland or pastureland is the approved post-mining land use or for incidental erosion-prone areas when soil stabilization is the principal concern. In such cases, only endophyte-free fescue should be used (Burchick, 1993). Seeding rates 20-40 lbs/A, for late spring or fall, higher end of range should be used, and a reduced rate should be used when seeded within mixtures of grasses or legumes.

Species: Red Fescue *Festuca rubra* L.
Varieties: Fortress, Creeping red fescue, Common
Characteristics: Long-lived grass species with fine stems. Acid tolerant (pH 4.5-8.5) and moderate drought tolerant. Does not produce high yields but gives good ground cover and may be less competitive than tall fescue when trees are to be established in these plantings. Seeding rate 20-30 lbs/A. Rates should be increased for late planting; rates should be reduced when planted in mixtures.

Species: Redtop *Agrostis alba* L.
Varieties: Common
Characteristics: Moderately long-lived grass species, which is little more acid tolerant than tall fescue (pH 4.0-8.5). It is a fine stemmed grass that does well in wet or poorly drained sites once established. However, it is also moderately drought tolerant. It gives good ground cover, moderate forage yields. Seeding rate 4-8 lbs/A.

Species: Perennial Ryegrass *Lolium perenne* L.
Varieties: Omega, Revielle, Common: Penta is a turf type variety.
Characteristics: None of the varieties are true perennials although some remain longer than others under ideal management conditions. The tall types are rapidly established and effective in controlling erosion. Less acid tolerant than tall fescue (5.5-7.5), and seeding rates are similar to tall fescue (30-35 lbs/A). When seeded in mixtures, perennial ryegrass is dominant and may reduce or eliminate other species from the stand. Turf types of perennial ryegrass may be less competitive for areas where trees are to be established after 1 year. May also be used for temporary seedings if cover needed only for 1 to 2 years.

Species: Timothy *Phleum pratense* L.
Varieties: Clair (only one tested although others are available).
Characteristics: Moderately long-lived (5 years) grass that had moderate acid (pH 5.0-6.5) and drought tolerance. It is a bunch grass and may be used to partially substitute for tall fescue in reclamation mixtures. It produced moderate ground cover and forage yields. It may be substituted for tall fescue in wildlife mixtures.

Species: Kentucky Bluegrass *Poa pratensis* L.
Varieties: Troy, Kenblue, Parade, etc.
Characteristics: Long-lived grass that has a moderate drought and acid resistance (pH 5.5-8.5). It does best on well to moderately drained area, however it is slow to be established. Moderate forage yields were obtained on mined land, especially the second and third years. Seeding rate is 15-25 lbs/A and should be established in periods where drought stress is not expected.

Species: Orchardgrass *Dactylis glomerata* L.
Varieties: Boone, Hallmark, Benchmark
Characteristics: Long-lived grass species that is acid tolerant (pH 4.5-7) but not exceptionally drought tolerant, especially for newly established stands. It may be substituted for part of tall fescue in grass mixtures, but pure stands have not been too successful. Seeding rates of 15-20 lbs/A for spring, 15-30 lbs/A for fall seedings, but seeding rates reduced when in mixtures.

Species: Reed Canarygrass *Phalaris arundinacea* L.
Varieties: Common
Characteristics: Long-lived sod-forming grass species that spreads by rhizomes but usually initially established from seed. It is well suited for wet areas, but it also is adapted to droughty sites. It is slow to be established as seed germination is low. It has a moderate acid tolerance (pH 5.8-8.5). Seeding rate 10-15 lbs/A, but rates should be increased by 5 lbs/A for fall seedings. May be planted in mixtures but usually results are poorer.

Cool-Season Grasses (Marginal for Kentucky)

Species: Canada Bluegrass *Poa compressa* L.
Variety: Reubens
Characteristics: Moderately to long-lived grass species that is both acid (pH 4.5-8.5) and drought tolerant. It does fairly well on soils or spoils that are low in fertility in which little production is needed. It gives reasonable ground cover and spreads because it produces good seed quantities. It is shallow rooted and may be suited for areas in which trees are to be established later. Seeding rate 10-15 lbs/A and should be reduced when planted in mixtures. Better success in establishment was achieved in early fall plantings.

Species: Smooth Brome Grass *Bromus inermis* Leyss.
Varieties: Common
Characteristics: Moderately long-lived seasoned grass with moderate acid tolerance (pH 5-7). When established is a good sod-former grass species that is moderately drought tolerant. Kentucky is the lower limit of its use and may be more successful in eastern Kentucky, although not aware of its being planted in research plots. Seeding rates are similar to those of tall fescue in wildlife plantings or forage mixtures. In pure stands, moderate forage yields were obtained.

Species: Hard Fescue *Festuca ovina* L. (var. *duriuscula* L. Koch.)
Varieties: Scalds, Dura
Characteristics: Seeding rate 15-30 lb/A (See Fine fescue)

Species: Meadow Fescue *Festuca elatior* L.
Variety: Bundy
Characteristics: Seeding rate 20-30 lb/A (See Fine fescue)

Species: Fine Fescue *Festuca ovina* L.
Variety: (Experimental F-1377)
Characteristics: The above species appear to be drought tolerant as well as moderately tolerant to acidity (pH 5.0-8.0). However, these are all turf type cool-season grasses that have low forage production when harvested as hay. They do give good ground cover but are slow to be established. Competition may be less than tall fescue when trees are planted into these species. Seeding rate: Fine fescue: 5-10 lbs/A.

Species: Crested wheatgrass *Agropyron desertorum* Schult.
Variety: Norden
Characteristics: This is a cool-season, cold-tolerant grass commonly used in reclamation in the western U.S. It provides good ground cover and production for hay or grazing. It shows some promise for western Kentucky reclamation with limited testing. Although it will grow on acidic spoils (pH 4.5-5.5), it is one of

the better grasses for dry alkaline soils (pH 7.8-9.0). Seeding rates 12-15 lbs/A and may be seeded in early fall and spring. The species was introduced from Russia.

Species: Western Wheatgrass *Agropyron smithii* Rydh.
Variety: Common
Characteristics: (See below)

Species: Intermediate wheatgrass *Agropyron intermedium* Beauv.
Variety: Cahe, Tegmar
Characteristics: Both of the above species are long-lived, cold-tolerant grass species that are similar to crested wheatgrass in their use. They are not as tolerant to alkalinity but a little more tolerant to acidity than crested wheatgrass. The seeding rates range from 12-15 lbs/A. Yields are generally a little lower than crested wheatgrass because stands are not as thick, at least under Kentucky conditions. Both species would appear to be less palatable to livestock than crested wheatgrass.

Warm-Season Grasses for Permanent Cover

Species: Bermudagrass *Cynodon dactylis* L.
Variety: Common (Some new varieties of seed types of bermudagrass may be available but not tested. Sprigs of Midland and Coastal were planted but little survival was obtained.
Characteristics: This is a moderately short-lived grass species. It is relatively drought tolerant and acid tolerant (pH 3.5-7.5). It is subject to winter killing, especially where potassium fertility levels are low. For good forage yields, high nitrogen rates are needed. Has a special use in reclamation of acidic sandy spoils as a "nurse" crop for other long-lived cool-season grasses such as tall fescue. Although stands thin when tall, fescue is overseeded the fall of the 1st or 2nd growing seasons, some plants have been found after 5 years. Seeding rate, de-hulled seed - 10 lbs/A; unhulled seed - 25 lbs/A. Seeding should be done only in late April to late May.

Species: Weeping Lovegrass *Eragrostis curvula* Schrad.
Variety: Common (commercial varieties may be available)
Characteristics: This is a moderately to short-lived grass species that is drought and acid tolerant (pH 4-8). It established fairly rapidly but can reduce stands of other longer-lived cool-season grasses when it is seeded in mixtures. This grass has the tendency to convert to bunch grass growth habit. Good yields may be obtained with good management, but it is hard to manage so that animals will not normally graze it. Seeding rates 3-5 lbs/A and seeded only between March 1-June 30.

Species: Switchgrass *Panicum virgatum* L.
Variety: Blackwell, KY - 1625-77
Characteristics: This is a long-lived grass species that is moderately drought and acid tolerant (pH 4.5-8.0). It does best where adequate moisture is available. It is very slow to be established especially when seeded in mixtures with cool season grasses. Once established, high production is obtained, but forage quality for hay is unknown. It is one of the original tall prairie grasses of Kentucky and the western U.S. Seeding rates of 10-15 lbs/A and should be planted in the spring.

Species: Big Bluestem *Andropogon gerarda* Vitman.
Variety: Experimental KY-30-70, Kaw-75
Characteristics: (See below)

Species: Little Bluestem *Andropogon scoparius* Michx.
Variety: Common
Characteristics: Both of the above are grasses that are slow to be established and were originally part of tall prairie grass mixture. Production is good when established, forage quality good if grazed at short to medium growth stages. Growth is good even at pH levels as low as pH 4.5. Seeding rates used 15-20 lbs/A and seeded only in the spring months.

Species: Indian Grass *Sorghastrum nutans* L.
Variety: Experimental KY 591-76, Cheyenne
Characteristics: A grass species that is drought tolerant but slow to be established. This is a prairie grass and produces high yields once established. Similar to switchgrass with respect to characteristics and seeding rates (10-20 lbs/A).

Species: Deertongue *Panicum clandestinum* L.
Variety: Tioga
Characteristics: This is an acid-tolerant (pH 3.8-6.5) forage grass that is good for grazing. However, because seed is not plentiful, it has a limited use in reclamation. Seeding rates are unknown and it is assumed to be a warm-season grass.

Species: Buffalograss *Buchloe dactyloides* Englem.
Variety: (unknown)
Characteristics: A short growing grass - a part of short prairie grasses of the western U.S. It is drought tolerant, but because seed is expensive, it doesn't appear to be of importance in reclamation in Kentucky or western U.S. for large plantings. It has survived 5 years in experimental planting in western Kentucky. Seed rates used are 5-10 lbs/A.

Species: Sideoats Grama *Bouteloua curtipendula* Torr.
Variety: (unknown)
Characteristics: A long-lived grass that is drought tolerant. A part of the prairie grass mixture. Has little use in Kentucky reclamation, although has survived in a short prairie grass mixture for 5 years. Seeding rate used 5-10 lbs/A. **This species is (or has been) on the endangered species list in Kentucky**

Species: Blue Grama *Bouteloua gracilis* Lag Steud.
Variety: (unknown)
Characteristics: Similar to sideoats grama, drought tolerant, long-lived grass. Not likely to have a place in KY reclamation. A part of a prairie grass mixture. Seeding rates 5-10 lbs/A.

Species for Temporary Cover

Species: Annual Ryegrass *Lolium* L.
Variety: Common
Characteristics: A cool-season annual that is planted in the fall, harvested as hay in early late spring or summer. Used as a temporary quick cover for one winter as it usually does not reseed itself. Because it will dominate the stand, it may cause failure of the establishment of permanent grasses. It may be killed under severe winters. Seeding rate 18-25 lbs/A.

Species: Wheat *Triticum aestivum* L.
Varieties: Wakefield, Madison, Clark, Verne, Coker 9803, etc.
Characteristics: A winter annual grain group that may serve as a companion crop in establishment of permanent grasses but could cause reduction of these species. May be used to provide standing mulch or harvested for grain or mulch for other areas. May be used for grain production for prime land production requirements. Seeding rates 40-60 lbs/A companion crops, 90-120 lbs/A grain crop, and 120-160 lbs/A temporary erosion control.

Species: Rye *Secale cereale* L.
Varieties: Abruzzi, Wheeler, Aroostook, etc.
Characteristics: Use as a quick-cover winter annual companion crop or green manure crop. Because it is taller, it may reduce survival of interseeded grasses and legumes when high seeding rates are used. Seeding rates 40-60 lbs/A for companion crop, 90-120 lbs/A grain or mulch crop to be harvested for straw, and 120-180 lbs/A for temporary erosion control. Aroostook especially noted for erosion-control capacity.

Species: Millet
Varieties: Japanese, German
Characteristics: Summer annual grasses used as quick-cover crop for summer seedings. Good feed for birds.

Species: Grain Sorghum
Variety: Yellow, Atlas, Sudangrass Hybrid
Characteristics: Summer annual grasses used as quick-cover crop for summer seedings.

Species: Austrian Peas

Species: Sunflower
Variety: Peredovik

Species: Buckwheat

Cool-Season Legumes

Species: Birdsfoot Trefoil *Lotus corniculatus* L.
Variety: Fergus, Viking, Dawn, Empire
Characteristics: Birdsfoot Trefoil is a species that is long-lived species once established, and varieties listed above are in order of best to least with respect to this characteristic. This species cannot compete very well in early stages of establishment when the grasses (or weeds) are actively growing due to high nitrogen levels. Birdsfoot trefoil is both drought and acid tolerant (pH 4.0-8.2). Although relatively low growing, good forage yields may be obtained, especially when grazed. Once established, it is good for erosion control. May be seeded with tall fescue, orchardgrass, or timothy, but grass seeding rates should be reduced. Seeding rate 10-15 lbs/A; better success has been achieved in spring seedings than fall. Once established, it is one of the best legumes for reclamation.

Species: Alfalfa *Medicago sativa* L.
Variety: Vernal, Apollo, Arc, Vanguard, Williamsburg, Tempus, Trident, etc. (Those listed have been tested on mined land.)
Characteristics: A long-lived (5-7 years) legume that is traditionally grown on soils or spoils that have a near neutral pH (6.0-8.0). It will survive on more acid areas if adequate moisture and/or on spoils in which at least the upper 4-6 inches has been limed to pH 6.5. Alfalfa requires high fertility if high production is to be achieved, however, it will survive under low fertility conditions. Although some varieties are insect resistant, production may be reduced for the first (and second) harvest if insecticides are not used. Compatible with grasses and other legumes. Seeding rates of 10-20 lbs/A are used in mixtures or pure stands. One of the better legumes for reclamation.

Species: Red Clover *Trifolium pratense* L.
Variety: Kenstar, Kenland, Redland, Redman, Cinnamon. (Those listed here have been tested on mined land.)
Characteristics: A short-lived (usually 2-3 years) legume that under proper management may stay in a stand for longer periods. Good production if used for forage under good fertility. It is not nearly as drought or acid tolerant as Birdsfoot Trefoil and grows best when pH is near neutrality (pH 6-7.5). With proper seedbed preparation and conditions, it is easily established with best results for spring seeding at 15-25 lbs/A.

Species: White Clover *Trifolium repens* L.
Variety: White Dutch (Ladino)
Characteristics: A legume that may be short-lived species as it requires some seed production to maintain a good stand. Because of its low growing habit, it will produce low forage yields. Should always be planted with a grass. Adapted to neutral pH levels (pH 5.8-7.5). Seeding rate 5-10 lbs/A.

Species: Alsike Clover *Trifolium hybridum* L.
Variety: Common
Characteristics: Similar to red clover and dies out after two years. It is a legume that does well in wet areas. May be seeded with tall fescue. It is more acid tolerant than red clover. Establishes best in the spring using 12-18 lbs/A. Even when it is allowed to go to seed, it does not remain as long as red clover even under good fertility and management.

Species: Crownvetch *Coronilla varia* L.
Variety: Common (May be some commercial varieties available but to date none have been tested on mined land in Kentucky)
Characteristics: A long-lived legume if not grazed heavily. Should be used only on incidental erosion-prone areas where soil stabilization is the principal concern. This species should not be used for the purpose of wildlife habitat. Slow to be established from either seed or space planted seedlings, especially when seeded with tall fescue. Well adapted to steep areas and where pH's are above 6.0. Once it is established, it is effective in erosion control and aggressive with respect to domination of the stand. Fall plantings are less successful than spring seedlings. The seeding rate 10-15 lbs for fall, 5-10 lbs for spring; seed is very expensive, but well worth it, if only a few well-spaced plants occur because this legume has a good spreading habit.

Species: Sweet Clover (yellow) *Melilotus officinalis* L.
Variety: Common yellow blossom
Characteristics: A short-lived or biannual legume, but a good reseeder will usually remain in a stand. Not useful for hay or grazing but will serve to increase nitrogen (a green manure crop) in spoils. Established rapidly when under good conditions and may suppress other plants in which it is seeded. Although has survived on acid spoils (pH 5-6), it grows best at neutral pH's. It is drought resistant. Plant only the yellow blossom types at 15-25 lbs/A. May be used as a green manure crop and to reduce bulk densities of subsoil horizons of reconstructed prime farmland sites.

Warm-Season Legumes

Species: Sericea Lespedeza *Lespedeza cuneata* G. Don.
Variety: Common, Interstate, Cericea, Serala
Characteristics: A long-lived legume that has a moderate acid (pH 4.5-7.0) and good drought tolerance. Widespread use of this species is discouraged. Should only be used on incidental erosion-prone areas where soil stabilization is the principal concern. This species should not be used for the purpose of wildlife habitat. It is slow to be established when adequate nitrogen is applied for the grass, but once it becomes established, it will dominate the stand primarily used for hay/pasture land use. Therefore, it would need to be maintained. Does not perform well when cut regularly. Stands are more successfully obtained in the spring and fall seedings. Hulled seeds should be used in fall planting, and unhulled seeds should be used in spring planting. The seedlings that germinate in the fall usually do not survive. Seeding rate 15-25 lbs/A. Low food value for wildlife but provides good cover.

Species: Korean-Kobe Lespedeza *Lespedeza stipulacea* Maxim.
Variety: Usually sold as Korean or Kobe
Characteristics: An annual season legume that is a good reseeder if properly managed and not grazed intensively. It is acid tolerant (pH 4.5-7) but if production is needed as a hay, pH should be in 6-7 range. If harvested as hay, it must be reseeded. Good success is achieved when seeded with a grass mixture. Kobe is a little more manganese tolerant than Korean. Provides good wildlife food for birds such as quail. Seeding rates 25-30 lbs/A for Korean, 30-35 lbs/A for Kobe.

Species: Flat Pea Vine *Lathyrus sylvestris* L.
Variety: Limited seed available (USDA)
Characteristics: Long-lived legume that is drought resistant and acid tolerant. Some related species are poisonous, but not the above, which may be grazed. Little value other than conservation plantings due to limited seed sources and difficulty of establishing when planted with tall fescue. It may require some re-seeding to be able to maintain a long-lived stand. Seeding rate 5-10 lbs/A, drilled in rows or space planted.

Winter Annual Legumes

Species: Hairy Vetch *Vicia villosa* Roth.
Variety: Common
Characteristics: A legume that provides short-range ground cover. Serves as a green manure or source of nitrogen and erosion control when seeded with a cereal grain such as wheat or rye. Useful in wildlife plantings, but it should be seeded each fall as little carry over of seed from one year to the next occurs. Plant only in the fall (Aug-Oct) at 40-50 lbs/A (pure stand) or with grass, 20-30 lbs/A in mixtures with other legumes.

Species: Big Flower Vetch *Vicia grandiflora* Scop.
Variety: Unknown or common - some new varieties may be available.
Characteristics: A legume similar to hairy vetch that appears to have limited use in reclamation of non-topsoiled mined land. On non-mined land, it out yielded Hairy Vetch, but it did not reseed itself in two trials on mined land spoils, probably due to birds eating the seed. Seeding rate 25-35 lbs/A.

Table 12. Suggestions for Seed Mixes and Rates for Kentucky

<u>Cool-Season Grasses for Permanent Cover</u>	<u>Seeding Rate lb/acre</u>
Tall Fescue	20-40
Red Fescue	20-30
Redtop	4-8
Perennial Ryegrass	30-35
Timothy	4-9
Kentucky Bluegrass	15-25
Orchardgrass	15-20
Reed Canarygrass	10-15 (5 lb/Amore for fall seedings)
<u>Cool-Season Grasses (Marginal for Kentucky)</u>	
Canada Bluegrass	10-15
Smooth Brome Grass	20-40
Hard Fescue	15-30
Meadow Fescue	20-30
Fine Fescue	5-10
Crested Wheatgrass	12-15
Western Wheatgrass	12-15
Intermediate Wheatgrass	12-15
<u>Warm-Season Grasses for Permanent Cover</u>	
Bermudagrass	
hulled	10
unhulled	25
Weeping Lovegrass	3-5
Switchgrass	10-15
Big Bluestem	15-20
Little Bluestem	15-20
Indian Grass	10-20
Deertongue	unknown
Buffalograss	5-10
Sideoats Grama	5-10
Blue Grama	5-10

<u>Species for Temporary Cover</u>		<u>Seeding Rate lb/acre</u>
Annual Ryegrass		18-25
Wheat	companion crop	40-60
	grain crop	90-120
	temporary erosion control	120-160
Rye	companion crop	40-60
	grain or mulch crop	90-120
	temporary erosion control	120-180
Millet		10
Grain Sorghum		20

<u>Cool-Season Legumes</u>	<u>Seeding Rate lb/acre</u>
Birdsfoot Trefoil	10-15
Alfalfa	10-20
Red Clover	15-25
White Clover	5-10
Alsike Clover	12-18
Crownvetch	10-15 Fall
	5-10 Spring
Sweet Clover	15-25
Narrowleaf Trefoil	5-10

Warm-Season Legumes

Sericea Lespedeza	15-25
Korean-Kobe Lespedeza	25-30
Flat Pea Vine	5-10

Winter Annual Legumes

Hairy Vetch	40-50 Fall
	20-30 with other legumes
Big Flower Vetch	25-35

WOODY PLANTS

DEFINITIONS

Woody plants used in the revegetation of coal mines comprise both shrubs and trees. Deciduous shrubs and trees shed their leaves in the fall as part of their life cycle. Coniferous shrubs and trees are typically characterized as softwood and retain their leaves year-around.

PURPOSE

The use of trees and shrubs in the revegetation of mined lands not only plays an important role in providing wildlife habitat, but also is an integral element in achieving the post-mining land use. Trees and shrubs are essential in the post-mining land uses of forest and provide food and cover for the fish and wildlife post-mining land use. Trees and shrubs may be used as greenbelts to provide food and shelter for wildlife and for other post-mining uses as well.

REGULATORY REQUIREMENTS

Revegetation of land affected by coal mining must meet the criteria set forth under 405 KAR 16:200, including tree and shrub-stocking standards and criteria for measuring stocking success (TRM #19). A diverse, permanent vegetative cover must additionally meet the requirements delineated under 405 KAR 16:180 Protection of Fish, Wildlife, and Related Environmental Values and TRM #21. Certain areas on mines must meet additional requirements mandated by the Kentucky Division of Water under CWA Section 401 certification conditions for restored/replaced wetlands and riparian zones.

IMPLEMENTATION

Trees and shrubs are to be planted according to the locations and timetable specified in the MRP. Shrub and tree planting activities include:

- Species Selection
- Site preparation
- Planting

Species Selection

Trees and shrubs to be planted should be specified in the MRP. Species selection criteria for the purpose of achieving the post-mining land use include: benefits to wildlife, soil moisture, site drainage, slope and aspect, and soil and water quality. Ideally, marketable trees should be planted on more level ground to aid future logging for the forestry post-mining land use. Legume trees (alder, locust) and shrubs (autumn olive and shrub lespedeza) provide nitrogen to the soil. Mixing legumes with hardwood trees reduces the need for booster fertilizer. Pines tend to be drought resistant and acid tolerant. Willow, cottonwood, sycamore, and sweet gum are examples of trees that do well on wetter sites. Recommended trees and shrubs for the revegetation of coal-surface mined lands in eastern and western Kentucky are presented in Tables 13 and 14.

Table 13. Recommended Tree Seedlings for Kentucky

Hardwoods

Species: Cottonwood *Populus deltoides*

Hybrid Poplar:

Characteristics: Cottonwood and hybrid poplars are pioneer deciduous species, well-suited to disturbed sites. Eastern cottonwood grows naturally along stream banks and on bottom lands. These trees are fast growing and are spread from seed or cuttings. Grow best near pH 7. They do not grow well at pH levels below 5 or in soils that are compacted and dense.

Uses: Crating, veneer baskets, pallets, pulpwood and Furniture frames.

Species: Sycamore *Platanus occidentalis*

Characteristics: A rapid-growing deciduous that may tolerate both wet or dry soils but does best on well-drained alluvial soils. They tolerate a pH range 4-8 but optimum pH 6.0-7.5. Tolerant of competition from other tree species except black locust. They may be established from both seed and cuttings, but direct seeding required constant moisture while germinating.

Uses: Furniture parts, boxes, millwork, flooring, particle board, and paper.

Species: Green Ash *Fraxinus pennsylvanica* var. lanceolata

Characteristics: A small to medium-size deciduous tree that will tolerate pH levels 4.0-8.1. This species grows naturally in alluvial soils along rivers and brooks. Established from cuttings. Direct seeding is not recommended.

Uses: Tool handles, sporting goods, furniture pulpwood and fuel wood.

Species: White Ash *Fraxinus americana*

Characteristics: A moderate-size deciduous tree, less widespread than other ashes. Although it will grow at pH as low as 4, it does best at higher values. Established from one-year old-seedlings, direct seeding not recommended and older seedlings are too large to economically plant on spoils.

Uses: Tool handles, sporting goods, furniture and fuel wood.

Species: European Black Alder *Alnus glutinosa*

Characteristics: A medium-size deciduous tree that can tolerate extremely low pH levels - 4.0, but it does best near 7.0. It can tolerate both wet and dry soils. Although not a legume, alders fix nitrogen that is available to neighboring trees. Established from one-year-old seedlings or direct seeding.

Uses: Seed-wildlife food, wood charcoal, paper, particle board, and fuel wood.

Species: Gray Birch *Betula populifolia*

Species: Paper Birch *Betula papyrifera*

Species: European White Birch *Betula pendula*

Characteristics: Small deciduous trees, native to northern U.S. and high elevations of Appalachian states. Grows best on well-drained sandy loams having pH 4.0 or higher. Established from one year seedling.

Uses: Pulpwood and fuel wood.

Species: River Birch *Betula nigra*

Characteristics: The only native birch (river birch) to southern U.S. It is a medium deciduous tree that is comparatively short-lived tree species. It can tolerate pH as low as 4.0. Established from one-year-old seedlings on wet, poorly drained sites.

Uses: Limited due to its poor form.

Species: Silver Maple *Acer saccharinum* L.

Characteristics: A moderate to large deciduous tree that will tolerate wet or dry sites, but it does best on well-drained alluvial soils. May tolerate pH levels as low as 4, but does best at pH levels of 5-7.0. Established as one year old seedlings or direct seedings on moist sites.

Uses: Pulpwood, boxes, millwork, firewood, and pallets.

Species: Northern Red Oak *Quercus rubra*

Characteristics: A native deciduous tree that grows best on north or east slopes. Will tolerate pH as low as 4.0 but does best at 5-7.0. It will grow on heavy clays if moisture is available. Established from one-year-old seedlings.

Uses: Furniture, veneer, moldings, handles, and fuel wood.

Species: White Oak *Quercus alba*

Characteristics: Will grow on all but the driest or swampy sites if the pH is 5.0 or greater. Established from one year old seedlings.

Uses: Cooperage, furniture, veneer, fuel wood, pallets, and flooring.

Species: Black Walnut *Juglans nigra*

Characteristics: A large deciduous tree that grows best in soils 6.0-7.5, that are deep, moist, well-drained. Poorly drained and droughty sites should be avoided. Established from one year old seedlings.

Uses: Veneer, furniture, gun stocks, and novelties.

Species: Black Locust *Robinia pseudoacacia*

Characteristics: A medium-size deciduous tree that requires a soil of pH 4.0 or greater but does better at pH levels of 6-8.0. Grows well on a large variety of sites except poorly drained, heavy textured. Established from one-year-old stock or treated seed from a local source. This species fixes nitrogen that benefits this and neighboring trees.

Uses: Fence posts and firewood and pasture for bees.

Species: Royal Paulownia *Paulownia tomentosa*

Characteristics: Native to China, but adapted to southeastern U.S. Grows best on moist, well-drained soils often on south-facing steep slopes. Established from seedlings one year old and in open areas as it cannot tolerate shade.

Uses: Export to make rice pots, bowls, wooden spoons, musical instruments, and religious furniture. Wood is light and strong and will not split even under rapid kiln drying.

Conifers

Species: White Pine *Pinus strobus*

Characteristics: Eastern white pine is the largest native conifer of the northeastern U.S. It grows on most soils, but it will do well on excessively drained or well-drained soils that are droughty. Growth poorest on clay or poorly drained soils. Its pH tolerance is 4.0-7.5. Established from two- or three-year old seedlings.

Uses: Building materials, furniture, doors, and window sashes, as well as a popular species for Christmas trees.

Species: Loblolly Pine *Pinus taeda*

Characteristics: A coniferous tree widely limited to states below the Ohio River due to its being damaged from ice and snow. Tolerant to other trees and/or grasses on soils from sandy loams to clays with pH levels 4-7.5. One-year-old seedlings are used for establishing.

Uses: Pulpwood, saw logs, veneer, posts, poles, and piling.

Species: Virginia Pine *Pinus virginiana*
Characteristics: An abundant conifer of Appalachian states that is fast growing. Can tolerate pH levels as low as 3.5 but natural stands found in soils pH 4.6-7.9. Grows best on clay loams or sandy loams that are moderately to well drained. One-year seedlings are preferred for planting.
Uses: Pulpwood and beneficial as wildlife species.

Table 14. Recommended Shrubs for Kentucky Wildlife Habitat

Species: Autumn Olive *Elaeagnus umbellata*
Characteristics: A shrub that is well adapted to a variety of spoil conditions. Grown on spoils with a pH as low as 3.2 but better in pH levels 4-7. It is a nitrogen fixer and assists in building the soil. Plant one-year-old seedlings and may be interplanted with oak, walnut, and ash to "train" or shade out lower branches.
Uses: Wildlife food and nitrogen fixer.

Species: Tatarian Honeysuckle; Amur Honeysuckle; Bi-color Lespedeza; Japonica Lespedeza, Shrub Lespedeza, and bristly locust.
Characteristics: All of the species listed above are tolerant to moderately acidic conditions (pH levels 4.5 - 7.0). They may be used to provide both food and wildlife cover. Established from cuttings and/or seed.

Site Preparation

Typically, trees and woody plants are established on areas where grasses had been planted the previous year. However, planting trees and grasses within the same time frame may help to reduce competition early on. Another approach that may be considered is to band apply a constant herbicide in strips one to two months prior to tree planting. This reduces competition for moisture, yet provides soil protection. The use of a tree setter, following a shallow subsoiler or ripping, may improve tree seeding survival. Ideally, minimum grading will result in a less compacted soil but approval will be needed from the Cabinet.

Planting

Planting rates and timetables for woody plants should be specified in the MRP. Forested lands should be planted to a density of at least 300 trees and shrubs per acre as counted with a statistical confidence of 90 percent with trees comprising at least 75 percent of the woody plant species (Kentucky DSMRE TRMs #19 and 21).

Seedlings may be bare rooted or in small, individual containers. Direct planting of seeds may be used, but they are slow to germinate, and may not compete with grasses. For this reason, seeds should be planted to supplement seedlings.

Bare-rooted seedlings come from suppliers in bundles. (Each spring the Kentucky Division of Forestry sells them at reasonable rates (Appendix D). The roots should not be allowed to dry out. If they cannot be planted soon after delivery, a trench should be dug and the seedlings placed into the trench without folding the roots. The roots should be covered with soil and tamped down with the foot.

Because the roots of containerized seedlings are protected, their survival rate is greater, and they afford greater flexibility for planting schedules. Containerized seedlings have a higher unit cost, but this expense is balanced by less need to replant, thereby expediting bond release.

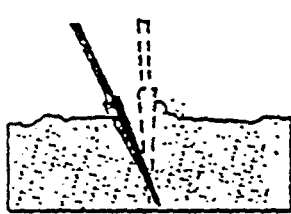
Seedling containers are of three types: tube, block, and plug. Tubes and blocks can be planted by machine. Tubes are made of a biodegradable material; blocks are composed of growing media (e.g., peat moss, vermiculite). Plugs must be planted by hand and are composed of soil that has been formed in a mold. Molds can often be reused.

In the machine planting of seedlings, equipment should be run on the contour where slope permits. Otherwise, work at right angles to the contour, up and downhill. Seedlings that require hand planting can be set using a mattock, dibble, or spade (Figure 25). Punch a hole to a depth so that the roots will not bend. Set the seedling no deeper than it was at the nursery. Tamp down the soil. Further information about the planting of tree and shrub seeds and seedlings is available through a district forester (Appendix D).

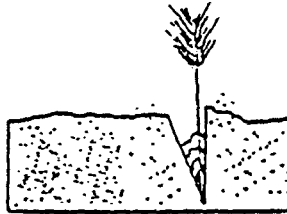
MAINTENANCE

Revegetative success can be measured using procedures provided by the Kentucky Department for Surface Mining Reclamation and Enforcement's TRM #19 (1991). Poor stands should be resown, following re-evaluation of soils and/or spoils in terms of acidity and fertility. As noted above, certain areas may need to meet requirements mandated by the Kentucky Division of Water.

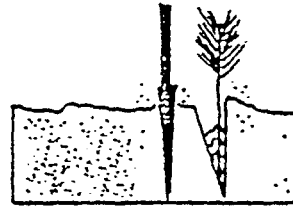
Dibble bar Planting



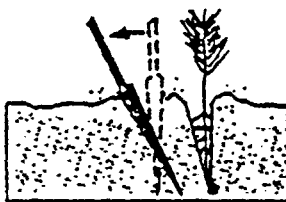
Insert dibble bar at angle shown and push forward to upright position.



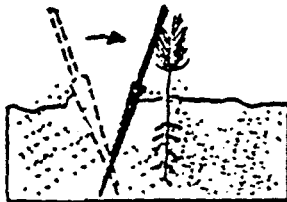
Remove dibble bar and place seedling at correct depth.



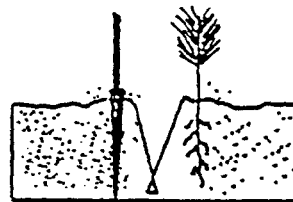
Insert dibble bar 2 inches toward planter from the seedling.



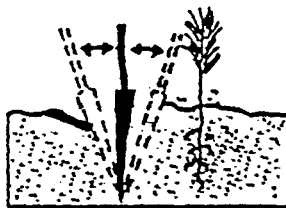
Pull handle of dibble bar toward planter, firming the soil at the bottom of the roots.



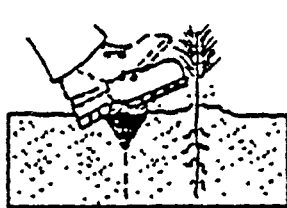
Push handle of dibble bar forward from the planter, firming the soil at the top of the roots.



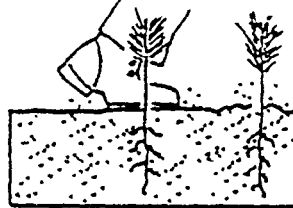
Insert the dibble bar 2 inches from the last hole.



Push forward then pull backward filling the hole.

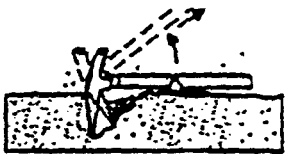


Fill in the last hole by stamping with heel.



Firm soil around seedling with feet.

Mattock Planting



Insert mattock, lift handle and pull.



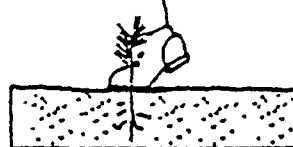
Place seedling along straight side at correct depth.



Fill in and pack soil to bottom of roots.



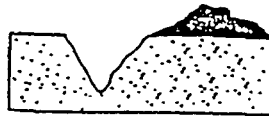
Finish filling in hole with soil and firm soil with heel.



Firm soil around seedling with foot.

Figure 25. Seedling planting techniques

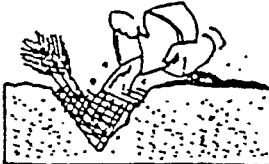
Heeling In



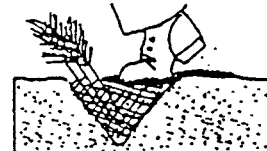
Dig a v-shaped trench in a moist shady place.



Break bundles and spread out evenly.

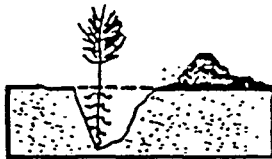


Fill in with loose soil and water.



Complete filling in with soil and firm soil with foot.

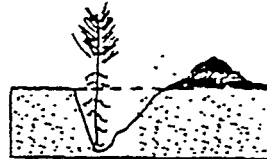
Correct and Incorrect Depths



Correct - At the same depth or 1/2 inch deeper than seedling grew in the nursery.

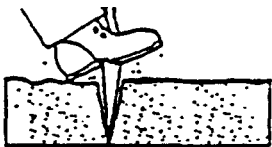


Incorrect - Too deep and with roots bent.

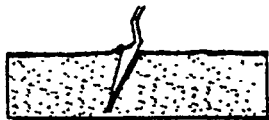


Incorrect - Too shallow and roots exposed.

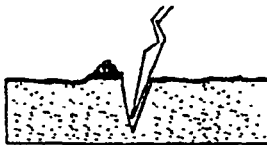
Spade Planting



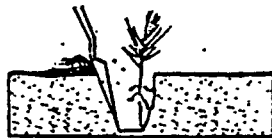
Shovel in position for starting planting hole. Blade reversed, perpendicular.



Shovel handle pushed forward. Bottom of hole opened up and out. Shovel pulled back and out of hole.



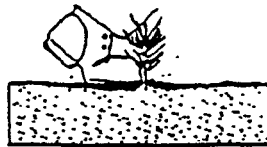
Beginning of second cut to straighten back wall of hole.



Shovel pulled back making clean hole. Tree placed in hole, roots in normal position. Plant tree 1/2 inch deeper than it formerly grew.



First packing, hole half filled with soil. If tree is in proper position, the shoe heel is used in tamping.



Second packing, hole completely filled. Cover packed soil with mulch or loose soil.

Figure 25. (cont.)

MULCH

DEFINITION

MULCH

DEFINITION

Mulch is a material that is spread over the surface of the soil. Examples of mulch materials include straw, hay, wood chips, bark, mushroom compost, excelsior, jute, and woven paper or plastic fibers.

PURPOSE

Mulch protects soil, seeds, and/or plant roots from the erosive effects of rain and minimizes fluctuations in soil moisture and temperature.

REGULATORY REQUIREMENTS

Section 4 of 405 KAR 16:200 requires the application of mulch in addition to a temporary vegetative cover on all regraded and topsoiled areas that have a slope in excess of 10 percent. The use of mulch may be waived on a case-by-case basis for those areas with slopes less than or equal to 10 percent if the Cabinet finds that based on seasonal, soil, and slope factors the temporary vegetative cover will achieve proper erosion control until a permanent cover is established.

IMPLEMENTATION

Establishment

Locally available, inexpensive materials are often preferred for use as mulch. Suggested mulching rates for selected materials are listed in Table 15. On steep slopes and sites with difficult accessibility consider the use of a blower or hydroseeder to apply mulch. This can sometimes be accomplished in conjunction with seed and/or fertilizer application. However, excessive use of mulch mixed with seed can result in poor stands.

Anchoring

Loose mulch should be anchored to prevent loss through erosion. Methods and materials used to anchor mulch include netting, disking, and asphalt spray.

MAINTENANCE

Mulched areas should be inspected, especially following wind and/or rain storm events. If necessary, mulch and seed should be replaced.

Table 15. MULCHING GUIDE

Mulching Material	Rates	Remarks
Small grain straw, tall fescue, or mixed hay	Apply uniformly with chopper-blower at the rate of 1.5 to 2 tons (60-80 bales) per acre. crimper.	One of the better mulching materials when tacked down with asphalt emulsion or other chemical binders or when pressed into the soil with a power mulcher. Can be applied by hand or
Corn Stalks	4-6 tons per acre	Air-dried; cut or shredded in 4"-6" lengths.
Shredded bark	Apply at rate of 45 cu. yds. per acre	Excellent mulching material that will stay in place without tacking down. Bark can be applied on leveled and sloping areas with the truck-mounted spreader. It can be applied with a manure spreader on leveled areas.
Wood fiber	Apply at rate of 1,400 to 1,600 lbs. per acre	Processed wood or cellulose fibers and some reprocessed paper materials are popular because they can be mixed with seed and fertilizer in a hydroseeder and applied all at one time. Most cellulose materials are colored for visibility.
Wood chips	10-20 tons per acre	Air dried; may contain bark.
Leaves	Apply at a rate of 2-3 tons per acre or 100 bales per acre	Use of deciduous tree leaves for mulching is limited to level areas because light disking is necessary to hold them in place. Leaves can be spread with a power mulcher or with a manure spreader.
Other waste products	Apply at a rate of 10 tons per acre	Waste products such as processed or compost garbage and dewatered sewage sludge can be used as mulches and organic amendments. Application can be made with truck-mounted spreader followed with a light disking.